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THE TECHNIC.

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A NEW term has started, and from the relaxation of a short vacation, we return to school. The duties and the pleasures of college life—and we hope that they are not wholly in contrast—are again before us. Few of us there are who do not wonder how brilliant they would be if they would study from the beginning of the term with the same intense and determined interest which marked the last few days of the past term. It is, of course, a bit commonplace to be making resolutions at this particular season of the year, but nevertheless one cannot help feeling that such a course of procedure would be a pretty good plan of action. THE TECHNIC hopes that the vacation has been a pleasant and profitable one to everybody, and takes this opportunity, the first which has offered itself, of wishing to all of its readers a year of pleasure, usefulness, and success.

THE Editor has for a long time hoped that in one direction there lay a possibility of increasing the usefulness of THE TECHNIC. It has been a noticeable feature of many courses of study in the Institute for the professor to give to his classes much valuable material, in the form of tables or otherwise, which could not be conveniently found in the ordinary sources of such information. In many cases, the tables are wholly original, and do not exist anywhere in the literature of the science. Especially with regard to tabulated information, the difficulty of arranging the data in such a way as to be most useful for different purposes is very great. Realizing the value of the material, which seems available and is largely still in manuscript form, THE TECHNIC hopes to publish, at intervals, such portions of it as would be worth putting in a more permanent form. The first of these will appear with the February issue.

IN a letter dated October 15, last, Dr. T. C. Mendenhall resigned his position as President of the Worcester Polytechnic Institute. His health had for some time been impaired, and the necessity for a rest had become evident. The resignation takes effect on July 1. Shortly after this he expects to go to Europe, where he will probably remain several years. The seven years of Dr. Mendenhall's connection with Worcester have been extremely successful, and deep regret was expressed by every one who knew him at the necessity of his resigning. Dr. Mendenhall was President of the Rcse Polytechnic Institute from 1886 till 1890, and his administration was a very able one indeed. His success at the Institute, and his charming personality, gained for him a large number of admirers and friends during his stay in Terre Haute. To Dr. Mendenhall THE TECHNIC owes an especial debt, as the idea of its establishment originated with him, and his suggestions did much to outline the original policy of the paper. THE TECHNIC hopes most sincerely that the expected vacation will be of great benefit to him, and that the time may not be long before his health is completely regained.

THE American Chemical Society met in Chicago Dec. 27-28. The meetings were held partly at the Lewis Institute, partly at the Northwestern University Medical School. About 130 were in attendance, a few coming from New York, Washington, Georgia and other places at a considerable distance. The majority, however, were from Chicago and contiguous territory, there being seventy five members in the Chicago Section of the society.

Thursday morning several papers were read, the most interesting being on a simple test for the detection of Oleomargerine, on the use of sodium as a reducing agent in blowpipe analysis, and on the formation of sodium tetrasulphate during the distillation of a mixture of sodium nitrate and sulphuric acid. During the afternoon of Thursday the members of the society visited Frazier & Chalmers, manufacturers of mining and power machinery, the Consumers' Ice Co., and the tanneries of the American Hide and Leather Co. In the evening, the President, Dr. William M. McMurtrie of New York gave his very interesting address, "The Education required as a Preparation for Work in Technical Chemistry." After the address there was a "Commers" at the Technical Club, where the members sang German songs and brought back remembrances of old student days when many of them lived in Germany. Friday morning the annual reports were read and the report on the election of officers for 1901 was given. Professor F. W. Clarke, Chemist of the U. S. Geographical survey, was chosen President. He is well known for his work in recalculating atomic Weights and for his studies of the structure of silicates. Friday afternoon a visit was made to the stock yards, and Saturday morning to the works of the Illinois Steel Co. and of the American Smelting and Refining Co.

The twenty-fifth anniversary of the founding of the society will be celebrated in April. The summer meeting will be held in Denver during the latter part of August. W. A. NOYES.

THE sixteenth annual meeting of the Indiana Academy of Science was held at the State House, Indianapolis, on December 26, 27 and 28. A program of sixty-seven papers had been prepared, most of the contributions relating to the five principal heads, Mathematics and Physics, Chemistry, Botany, Zoölogy, and Geography and Geology. In the department of Mathematics and Physics, while none of the papers were of epoch-making character, several were of considerable interest. Two papers read by A. L. Foley, entitled "The Absolute Dilatation of Mercury," and "Some Experiments in Fluorescence," were valuable. Dr. Mees, Dr. Gray, Prof. Kendrick and Dr. Johonnot attended the meeting of this section. While the Indiana Academy of Science does not have the national importance of the meetings which draw their materials from the entire country, the showing made by it has been creditable indeed, and the hearty interest taken in its advancement by the scientists of the State is a good promise that it will be even more successful in the future.

Boiler Explosions.

BY F. C. WAGNER.

ACCORDING to the figures published by the Hartford Steam Boiler Inspection and Insurance Company, the average number of boiler explosions each year between 1879 and 1892 was 192 in the United States. In these explosions 263 persons were killed and 370 were injured each year on an average. The total number of killed and injured during the fourteen years covered by the statistics was 8,869. Nothing further needs to be said to emphasize the importance of studying the causes of boiler explosions.

The most natural explanation of a boiler explosion is that the pressure has been allowed to rise above what the boiler will safely stand. If this is true, the explanation is a good one and will certainly account for the explosion. Nothing too strong can be said in condemnation of the man who operates his boilers at a pressure higher than he knows to be safe and in so doing endangers the lives of others, to say nothing of the possible damage to property. But there are instances where boilers have exploded in which the steam pressure just before the explosion is known to have been no higher than the boiler was designed to carry. Any boiler should be able to stand at least twice the working pressure before bursting, and it seems improbable that a simple rise of pressure can have caused an explosion, provided the boiler is sound and in good repair and is being properly operated.

What then is the cause of the exploding of a boiler when the pressure does not exceed what is supposed to be safe. A common answer to this question is "low water." If the water is allowed to get so low in a boiler that the plates over the fire are not covered, they will become red hot in a comparatively short time. If now cold feed water be introduced, falling upon the hot plates, steam will be generated rapidly and, it is assumed, with sufficient rapidity to cause an explosion.

Let us take as an example a common tubular boiler, 60 inches in diameter and 15 feet long, with a thickness of shell of five-sixteenths of an inch and a working pressure of 75 pounds per square inch. Let it be assumed that the boiler is filled with steam at 75 pounds pressure, that the water is all gone and that the lower half of the shell is heated to a red heat. If cold feed water be pumped into the boiler at a temperature of 62 degrees Fahrenheit, what will be the effect upon the pressure?

In the first place, the heat which is available for the instantaneous production of steam is that in the boiler plate. The weight of the heated boiler plate would be approximately 1,500 pounds. The average specific heat of iron for this range of temperatures is about 0.14. The temperature of steam at 75 pounds gauge pressure is about 320 degrees Fahrenheit. Consequently the total amount of heat which the iron can give up is $1{,}500 \times .14 \times (1{,}000-320)$ equal to 142,800 heat units, sufficient to make 124 pounds of steam additional. There are already in the boiler about 260 cubic feet of steam, weighing about 55 pounds. If the entire 124 pounds of water were introduced instantly and no steam were allowed to escape the pressure would rise to about 300 pounds per square inch. But in practice the water could not be introduced instantly. For a boiler of this size, the rate of feed would be about 30 pounds of water per minute, so that it would require four minutes to introduce enough water to raise the pressure to 300 pounds. In the mean time the safety valve would blow off, so that it is extremely doubtful if a pressure double that normally carried would be reached at all.

Actual experiments have been made to test this matter. The following is quoted from *The Locomotive* for December, 1896:

"In April, 1868, the Pennsylvania Railroad

Company made a series of experiments at Kittanning Point which are thus described: 'The object was to blow up a boiler by introducing cold water on a red hot crown sheet, the maximum steam pressure being on the boiler at the time. In conducting the experiments the boilers were first fired up until 125 pounds of steam were obtained and the water was low, and then, through 1,000 feet of hose, cold water was forced into the boiler by means of a steam fire engine; and every attempt at exploding a boiler in that manner failed. Two boilers were experimented on, the first one becoming leaky after several trials, and being of no further use in that way. The second boiler was tried a few times, and finally blew up when least expected, seemingly from excessive pressure and weakened fire-box. The crown sheet blew down and the boiler turned a complete somersault and then rebounded and fell down the side of a hill, the spectators scattering very fast, and seeking shelter behind convenient trees. Nobody was hurt.' "

"In 1875 a commission appointed by the United States Government made a series of similar experiments at Sandy Hook. The boiler experimented upon was of the plain cylindrical type, set in brickwork in the usual manner. In each experiment the boiler was filled with water, a fire started, and when the fire was in good order and the steam at the right point, all water was blown out; the boiler was allowed to become heated to the desired temperature, as indicated by a pyrometer inserted within it, and at the proper moment the feed water was introduced by force pump. It was only on the second day that this severe usage produced the destruction of the boiler. At each occasion, on the introduction of the water, the steam pressure jumped up suddenly, the safety-valve opened, and, the water still continuing to enter, the boiler pressure dropped almost as rapidly as it had risen, and the boiler cooled down on each occasion (except the last) without apparent injury, and without having even started a seam, although the metal had been red-hot. The last experiment resulted in the explosion of the boiler and the destruction of its setting, and interrupted the work. The succession of phenomena in this case was precisely as described, but the temperature of the boiler was higher, probably a bright red on the bottom, and the pressure of steam was about 60 pounds when the explosion occurred. It had fallen somewhat from the maximum which had been attained the moment before."

It is to be observed that in both of these experiments the explosion was caused, not by the excessive pressure due to the introduction of feed water upon the heated plates, but to the weakening of the plates themselves in consequence of the repeated heatings and sudden coolings.

Another theory which has been advanced is that if water is thrown upon a red-hot iron plate, it may be split up into its chemical components, oxygen and hydrogen, the oxygen being absorbed by the iron producing iron rust and the hydrogen being set free. If the hydrogen be then brought into contact with other oxygen at a sufficiently high temperature it will combine explosively. This theory was condemned many years ago by Michael Faraday, who showed that the iron would very soon be covered by sufficient rust to prevent further action and that the amount of hydrogen which could thus be formed would be so small that it could not possibly produce an explosion.

Still others have sought to explain boiler explosions by some sort of electrical action. It is known that when a jet of steam issues into the open air through certain kinds of orifices an electric charge can be obtained from it. Some have reasoned from this that the steam in the boiler is filled with electricity and that the explosion is due to it. In reply to such a hypothesis, it may be said that the electricity produced by the steam jet is probably due to the friction of the steam against the sides of the orifice. There is no evidence that there is electricity in the steam as it exists inside the boiler. The gist of the electrical argument seems to be as follows: Boiler explosions are mysterious. Electricity is mysterious. Therefore boiler explosions are caused by electricity.

The truth of the matter is that there is no one universal explanation of boiler explosions. In the great majority of cases the explosion is doubtless due to some defect in the boiler plates, either defects which were in the metal originally or defects which have developed since the boiler has been put into service. A consideration of some of the causes producing deterioration of boiler plates may be instructive.

In the first place, the strength of the boiler plate varies between wide limits. In tests made by Messrs. R. Napier and Sons, of England, upon 150 plates, the strength ranged from 32,400 to 62,500 pounds per square inch. Mr. Fairbairn found the strength of a broken plate taken from an exploded boiler to be only 10,600 pounds per square inch. Every plate that is used should be tested.

Again, there is a loss of strength due to punching the rivet holes. Fairbairn found this loss to be 20 per cent. Also, if the rivet holes do not exactly match they are sometimes brought together by driving in a drift pin. This stretches the metal and renders it less elastic for any further strains which may be made upon it. It is quite possible by the use of poor material and by faulty methods of construction to make boilers which to all outward appearances are abundantly strong and yet which are not really safe for use under ordinary steam pressures. In these days, when the testing of the strength of plates is so common and so easily done, there is little excuse for using poor material.

In specifying material for boiler plates special attention should be paid to the elongation, i. e., the amount the metal will stretch before giving way. This is much more important than a high tensile strength. In actual operation the boiler plates are subjected to heating and cooling, which produces expansion and contraction, and as the result often very severe stresses. Evidently, if the metal can stretch somewhat without breaking, it will accommodate itself to these stresses without being injured.

The English Board of Trade rule requires that the tensile strength shall be between 54,000 and 64,000 pounds per square inch, and that in normal condition the material must stretch not less than 18 per cent. in a length of 10 inches. Strips two inches wide should stand bending until the sides are parallel at a distance from each other of not more than three times the plate's thickness.

The rule of the Board of Supervising Inspectors of Steam Vessels of the United States provides that "Steel plates shall in all cases have an ultimate elongation of not less than 20 per cent. in a length of eight inches. It is to be capable of being bent to a curve of which the inner radius is not greater than one and a half times the thickness of the plates after having been heated uniformly to a low cherry-red and quenched in water of 82 degrees Fahr."

The specifications adopted by the American Boiler Manufacturers' Association in 1898 provide that: "Shell plates *not* exposed to the direct heat of the fire or gases of combustion, as in the external shells of internally fired boilers, may have from 65,000 to 70,000 pounds tensile strength; elongation not less than 24 per cent. in eight inches; phosphorus not over .035 per cent; sulphur not over .035 per cent.

"Shell plates in any way exposed to the direct heat of the fire or the gases of combustion as in external shells or heads of externally fired boilers, or plates on which any flanging is to be done, to have 60,000 to 65,000 pounds tensile strength; elongation not less than 27 per cent. in eight inches; phosphorus not over .03 per cent.; sulphur not over .025 per cent.

"Fire box plates or such as are exposed to the direct heat of the fire, or flanged on the greater portion of their periphery, to have 55,000 to 62,000 pounds tensile strength; elongation 30 per cent. in eight inches; phosphorus not over .03 per cent.; sulphur not over .025 per cent.

"For all plates the elastic limit to be at least one-half the ultimate strength; percentage of manganese and carbon left to the judgment of the steel maker."

"*Bending Test.*—Steel up to ½ inch thickness must stand bending double, and being hammered down on itself; above that thickness it must bend round a mandrel of diameter of one and one-half times the thickness of plate down to 180 degrees. All without showing signs of distress.''

Such rules as the above have not been adopted without good reason, and they emphasize the necessity of using only the best material and workmanship in the construction of steam boilers, and show that the required thickness of metal and a good external appearance are not sufficient.

Not infrequently flaws in the material show themselves only after a considerable lapse of time. Sometimes a very small flaw is extended by the alternate bending in opposite directions, produced by the heating and cooling of the plates. In the year 1859 there were 1,618 boilers under the care of the Manchester Boiler Asssociation. Among these there was but one explosion, but no less than 14 boilers were found to have developed into a dangerous condition, and 100 into an unsatisfactory condition from *fracture of plates*. Among the same boilers in the same year there were 44 cases of dangerous corrosion and 153 cases of corrosion which rendered the boilers unsatisfactory. It is presumed that the most of these boilers had been inspected during the previous year, and the fact that so many were found to have *become* dangerous and unsatisfactory emphasizes the need of frequent inspection and constant watchfulness over the condition of the boiler plates.

The report of the Hartford Steam-boiler Inspection and Insurance Company for the year 1893 shows that of the 163,328 boilers inspected, 597 were found unsafe for further use. The classification of the dangerous defects found is given as follows:

Whole number of dangerous defects	12,390
Deposit of sediment	548
Incrustation and scale	865
Internal grooving	148
Internal corrosion	397
External corrosion	536
Defective braces and stays	485
Settings defective	352
Furnaces out of shape	254
Fractured plates	640
Burned plates	325
Blistered plates	164
Defective rivets	1,569
Defective heads	350
Leakage around the tubes	2,909
Leakage at seams	482
Water-gauges defective	660
Blow-outs defective	425
Deficiency of water	107
Safety-valves overloaded	203
Safety valves defective	300
Pressure gauges defective	552
Boilers without pressure gauges	115
Unclassified defects	4

Why should these defects produce an explosion? Why does not the weak spot simply give way and let the steam escape at that point instead of blowing the whole boiler apart? In many cases *such is the result*, but in many others there is a terrific explosion in which the shell of the boiler is torn apart and hurled to a considerable distance. The following explanation was given by Mr. Zerah Colburn a number of years ago, and seems to meet with general endorsement from men qualified to speak upon such matters.

Suppose a boiler to be working under pressure with a sufficient quantity of water in it. Let some part of the shell in the steam space give way, letting out a large amount of steam very quickly. Immediately a large amount of steam will be formed from the overheated water, because when the pressure is removed the water must give up a part of its heat, so that its temperature may correspond with the reduced pressure. The heat thus set free, as it were, generates instantly a large amount of steam, which, rising with tremendous velocity through the remaining water, drags the water with it and hurls it against the top of the shell, delivering a sledge-hammer blow that is irresistible. This blow tears the shell apart and then the steam pressure back of the shell pushes the shell before it, continually increasing its velocity until it is projected high into the air or thrown against some solid obstruction.

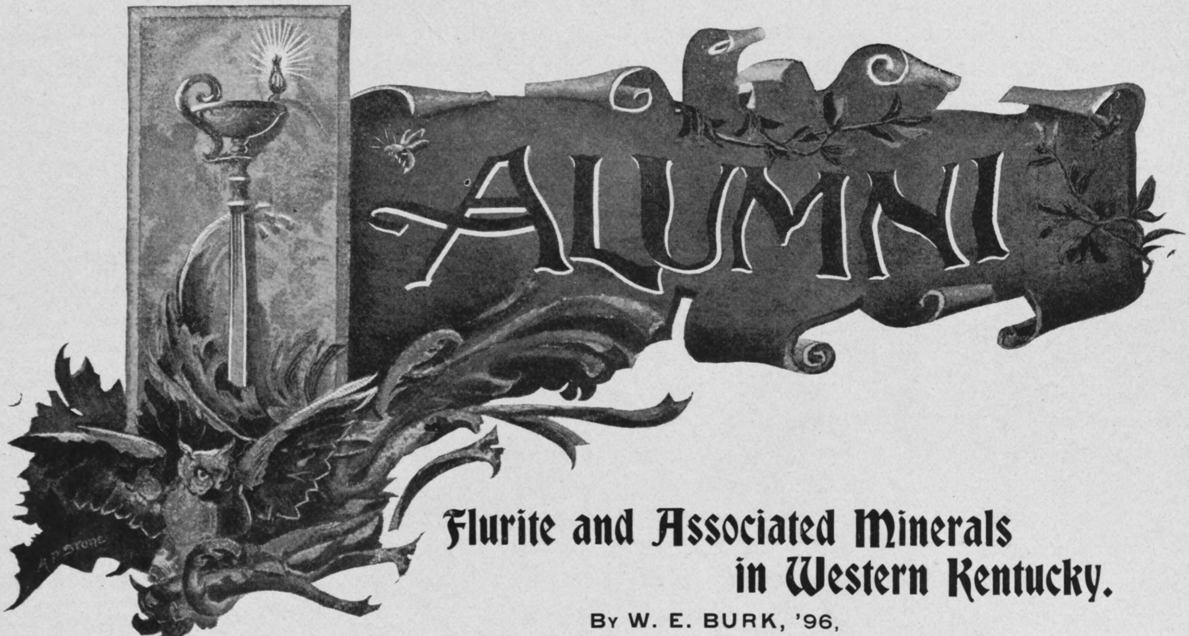
The fact that when the pressure is removed, hot water from a boiler flashes into steam, is familiar to every one who has watched a try-cock connected below the water level. The amount of steam which will be formed under given conditions is readily calculable by the use of a steam table. Let there be 8,255 pounds of water in a 60-inch tubular boiler, working under 75 pounds gauge pressure. Suppose the steam pressure to be suddenly reduced to 20 pounds by the giving way of some part of the boiler. The heat which will be set free instantly will be $8255 \times (1179.6 - 1161.0) = 153,543$ heat units, sufficient to generate 165 pounds of steam at 20 pounds pressure, which would fill a space 19 times as large as the steam space of such a boiler.

The pressure acting upon the water at the instant the pressure in the steam space is reduced is 75 pounds per square inch. By means of this pressure, which is maintained at nearly its full value by the evaporation of a part of the water into steam, the whole mass of water is lifted. A simple calculation will show that the average pressure forcing the body of water upward will be at least 70 pounds per square inch,—this pressure acting up to the point where the water strikes the top of the shell. In other words, the water acts like a huge piston with an average steam pressure of 70 pounds per square inch back of it and a pressure of 20 pounds in front. The amount of energy in the whole mass of water under these conditions is found by multiplying the volume of the steam space by the average difference of pressure between the two sides of the water in pounds per square foot. In the boiler considered the steam space is 101 cubic feet, so that the energy in the water as it strikes the shell is $(70-20) \times 144 \times 101$ equals 727200 foot-pounds. The blow delivered would correspond to that given by a weight of 18 tons falling a distance of 20 feet. The strongest boiler ever built could not withstand such a fearful blow.

After the shell has given way the steam continues to push upon the shell until the pressure is reduced to that of the atmosphere. In the present case, if the boiler were out in the open the steam would continue to exert pressure until the boiler had been thrown 15 feet from its starting point.

Sometimes mechanical stresses are produced in the shell of a boiler owing to improper method of support. The boiler pressure, when added to such initial stress is liable to produce a breakdown and perhaps an explosion. A case of this kind occurred at the Warrenby Iron Works, near Redcar, England, June 14, 1895. Eleven boilers exploded at one time. The boilers were of the plain cylindrical type, heated by the gases from blast furnaces. They were 66 feet long by 4 feet 6 inches in diameter, carrying 60 pounds pressure. There were fifteen boilers in line, eleven of which exploded. Some of them were blown a distance of 250 yards. All eleven boilers gave way on a girth seam, ten of them at the third ring and one at the fourth ring from the firing end. There was no great corrosion or scale. The coroner's report stated that the explosion was due to low water and consequent overheating. A fuller investigation by the Board of Trade brought out the fact that the boilers had ripped in a similar manner before without producing an explosion and that the trouble was due to mechanical strains arising from an improper method of supporting a boiler of such great length.

The greatest boiler explosion that has occurred in the United States was probably due to a similar cause. On October 11, 1897, twenty-seven boilers exploded at one time at Shamokin, Pa. The boilers were of the plain cylindrical type, 43 feet long and 34 inches in diameter. Both longitudinal and girth seams were single riveted, so that so far as the stresses produced by the steam pressure alone are concerned, the girth seams were twice as strong as the longitudinal seams. Notwithstanding this, the fractures were nearly all in the roundabout direction, showing that mechanical stresses induced by improper support, either existing originally or caused by the explosion of the first boiler, were responsible for the disaster.



Flurite and Associated Minerals in Western Kentucky.

By W. E. BURK, '96,
Professor of Chemistry, Male High School, Louisville, Ky.

FOR a long period of years the commercial demands of the United States for Fluor Spar or Fluorite have been almost wholly supplied by what has been termed the Roseclaire district of southern Illinois, with the town of Roseclaire on the Ohio river as the principal shipping point.

During the past few years, however, the deposit has been followed with some care, and developments have shown this district containing fluorite-laden veins to extend across the Ohio river and to include approximately the counties of Crittenden and Livingston in Kentucky.

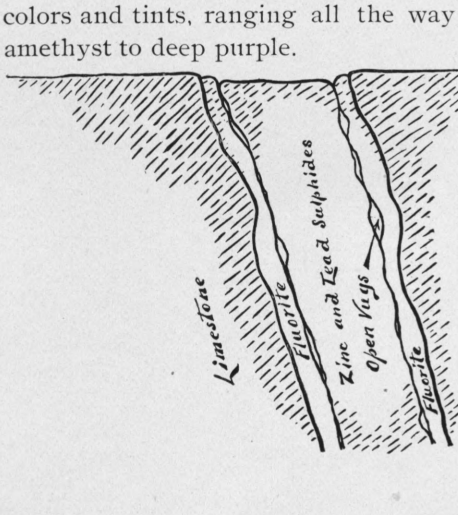
While the properties of this interesting though simple mineral have been well known, its use, until recent times, has had no extended application. But with the rapid advance and improvement in metallurgical processes during the closing decade, fluor spar has been welcomed as an efficient fluxing agent, especially in the smelting of iron ores and in the further working of the pig. In addition to this, the manufacturers of glass are consuming yearly increasing amounts of the mineral in the manufacture of opalescent glass ; and while the demands for hydrofluoric acid have not increased greatly, since its principal use is in the limited industry of glass etching—the total demands for all purposes have been increasing very rapidly. A consequent interest in this deposit has been awakened, with the result of a much better study and understanding of the district than heretofore. The district is crossed by many fissures and a few faults, most of them trending in a northeasterly by southwesterly direction, paralleling to a certain but very marked degree. The direction of breaks in connection with evidence of uplift along the same general directions suggest lines of weakness in sympathy with the Appalachian uplift.

Most of the mineral-bearing veins are in subcarboniferous strata, remnants of pre-existing coal-seams remaining at tops of some of the highest hills. The veins vary in width from a few inches to several feet, and in some notable instances as wide as twenty to twenty-five feet.

In the main they are vertical, or nearly so, and in many cases are filled from wall to wall with fluorite of the colorless massive variety, or where scattered, with a kind granular and white in appearance.

In nearly all veins, at more or less depth, are to be found traces and narrow seams of galena, while in many of them this leads at further depth to associated sphalerite. It is a common observation with the veins in which zinc ore has entered to find the amethyst or purple-colored fluorite; in fact, the association is so common that prospectors consider the purple fluor spar indication of zinc or lead ores at some little further depth.

At the Columbia mine in Crittenden county, Kentucky, which is the best developed opening in the district on zinc and lead ore, the replacement and succession of the mineral with increasing depth in fissure seems to be about as follows: First, galena coming in with the massive colorless fluorite vein filling; then galena increasing in percentage and being followed by sphalerite with the fluorite giving place largely to calcite; and finally resulting in a very rich ore body of zinc and lead with calcite gangue and practically no fluorite. At the surface at one spot on this vein the fissure is five to six feet in width, containing first against and along each wall six to eight inches of fluor spar, the same being highly colored where crystals are well developed. Within these wall linings of fluorite occur zinc and lead sulphides, filling the space; the mineral at this spot being a very pure sphalerite, (Black Jack) assaying 60% zinc. In the open vugs at the juncture of the zinc ore and the fluorite bodies cubical crystals of fluorite occur in large and well-developed clusters, possessing beautiful colors and tints, ranging all the way from pale amethyst to deep purple.



Section Across Vein.

The coloring and tinting of these crystals of fluorite is largely confined to the outer layer and especially to the edges of the crystals.

Not only does the position and occurrence of colored fluorite in open vugs represent the last mineral to crystallize from solution, but their colored edges—the last of their growth—seems to represent the last remnant of dissolved matter. Both of these facts strongly suggest metallic origin of the coloring matter of the fluorite.

Associated with the same and lead sulphides in the veins are appreciable percentages of iron, cadmium, and manganese in the form of sulphides and carbonates.

While deep fissures and faults exist in the district, as well as other evidence of uplift and much distortion, no igneous material is found, nor is anything seen that would suggest a vein filling by upward flow of a molten mass. This ever-ready popular explanation is accepted locally, but crystallization as well as all vein characteristics noticed tend to disprove it. The presence of fluorine, however, does at once suggest fumarolic action through deep subterranean connections, and this, together with general segregation has had much to do with the metalliferous vein-filling. Pay lodes exist at intervals along many of the veins, the same being probably of secondary formation. These have more or less commercial value (in most cases less) and some of them are now being worked in a desultory manner.

This nature of deposit of zinc sulphide as the leading metalliferous mineral in fissure veins is, I believe, unusual and entirely different from the Missouri-Kansas and Wisconsin fields, where the horizontal, "blanket" or lens formation of the ore body exists. Nearer this Kentucky deposit, in Arkansas, some similarity is met with in the way of more or less vertical leads, and it is not without significance to note the geographical proximity of all these mentioned fields, together with the central Missouri and southeastern Missouri deposits, which suggests a connected paragenetic system. This Kentucky-Illinois field is, however, peculiarly productive of fluorite, and in this is, I believe, unique and solitary.

It presents many interesting geological and mineralogical features, and will continue for many years to supply all demand for fluorite.

A few deposits of zinc and lead ore may be developed to a very profitable end, but on the whole the district can hardly be expected ever to compare with other producing fields of these heavy metals now being developed.

ALUMNI NOTES.

Mr. James R. McTaggart, '95, is connected with the Liquid Carbonic Acid Mfg. Co. as superintendent of the Pittsburgh plant, not of the Chicago plant, as stated in the November TECHNIC.

Among those who visited Terre Haute during the holidays were: Farrington, '96; Shaver, '97; Austin, '98; Crebs, Lickert and Smyth, '99; Brewer, Loufbourow and Madison, '00.

Jesse Holliger, '99, has resigned from the Vandalia to accept a position in the Carnegie steel plant, at Homestead, Pa.

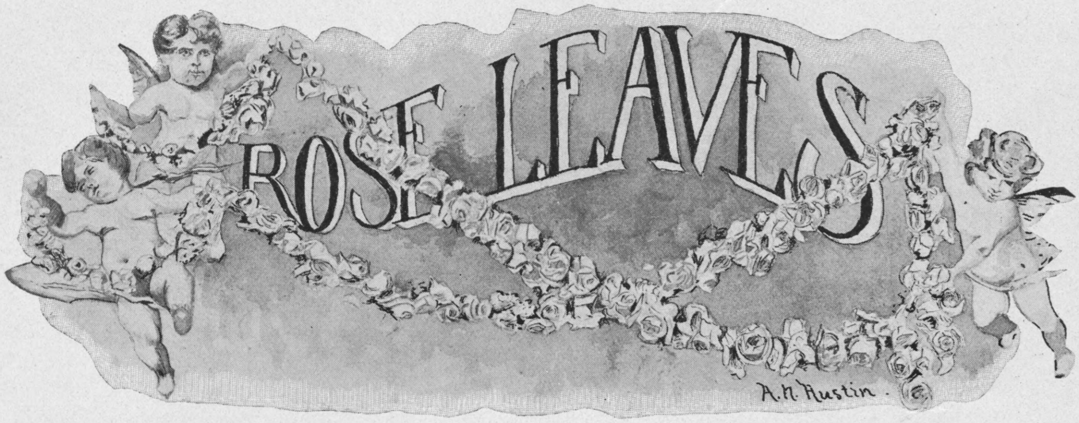
Uhel T. Carr, '96, and Frank J. Jumper, '99, are with the Pressed Steel Car Company, of Pittsburgh.

T. D. Witherspoon, '00, is with the Chicago Malleable Iron Castings Company, in Chicago. He is in the testing department. The statement made as to his employment in the October TECHNIC, it seems, was based on unreliable information.

The following invitation has been received:

Mr. and Mrs. Henry Augustus Sharpe request the honor of your presence at the marriage of their daughter, Lucy Gayle, to Mr. Arthur Clarke Eastwood, on Thursday afternoon, January the third, nineteen hundred and one, at two o'clock, at St. Mary's on the Highlands, Montgomery, Alabama.

Mr. Eastwood was of the class of '98. THE TECHNIC extends its heartiest congratulations to Mr. and Mrs. Eastwood.



Measurement of High Temperatures.

By WILLIAM HADLEY, '01.

THE measurement of high temperatures is a field of engineering which has been investigated quite extensively in the last few years, but the results of different investigators do not exactly agree. The thermometers in common use are the alcohol and mercury thermometers (generally those containing mercury). But neither can be used to measure very high temperatures, as the boiling point of each of these liquids is quite low in comparison with the temperatures obtained under many conditions. A temperature of 450° centigrade may be measured with a mercury thermometer if the mercury is placed under pressure with nitrogen, and 500° C. may be attained if liquid carbon dioxide is placed above the mercury-thread.

Above this point we must resort to the use of pyrometers, of which many different forms have been proposed or actually employed for measuring high temperature. The measurement is effected, (a) by contraction, as in Wedgewood's; (b) by the expansion of bars of different metals; (c) by change of pressure in confined gases, as in the air thermometer; (d) by the amount of heat imparted to a cold mass, as in Siemens' instrument; (e) by the fusing-point of solids; (f) by conduction or radiation of heat; (g) by change of velocity of sound; (h) by the resolution of chemical compounds; (i) by generation of electricity, as Becquerel's thermo-electric pyrometer; (j) by changes in resistance to electricity, as in the instrument invented by Siemens, which may not only be used far the measurement of high temperatures, but also for determination of very low temperatures.

I shall not attempt to describe all of these pyrometers, but will only try to detail some of the forms which are best, or most generally used in practice.

The Wedgewood pyrometer consists of clay balls, dried and accurately measured. They are then placed in the furnace and allowed to take on its temperature. They are then taken out and cooled and again measured. The shrinkage is the measure of the temperature. The composition of the clay is not changed, but the ball simply becomes more compact. These balls were first used by Wedgewood in the manufacture of pottery.

An iron or platinum bar, known as Daniel's pyrometer, is sometimes used. The bar expands when heated, and it is so arranged that the rod receives the temperature of the furnace, and the expansion is accurately measured. The co-efficient of expansion being accurately determined before the experiment, the temperature may be calculated with fair accuracy.

Another rough method consists of an iron or platinum ball placed in a furnace, and then transferred to a calorimeter without the loss of any heat, or with the loss of as small an amount of heat as possible. In this method, it is necessary to know the weight of the iron or platinum ball, the weight of the water in the calorimeter, the weight of the calorimeter, their specific heat and the temperature of water before and after experiments.

Σ=mass of ball.

m=mass of water.

M_1=mass of calorimeter.

S=specific heat of water=1.

S_1=specific heat of calorimeter.

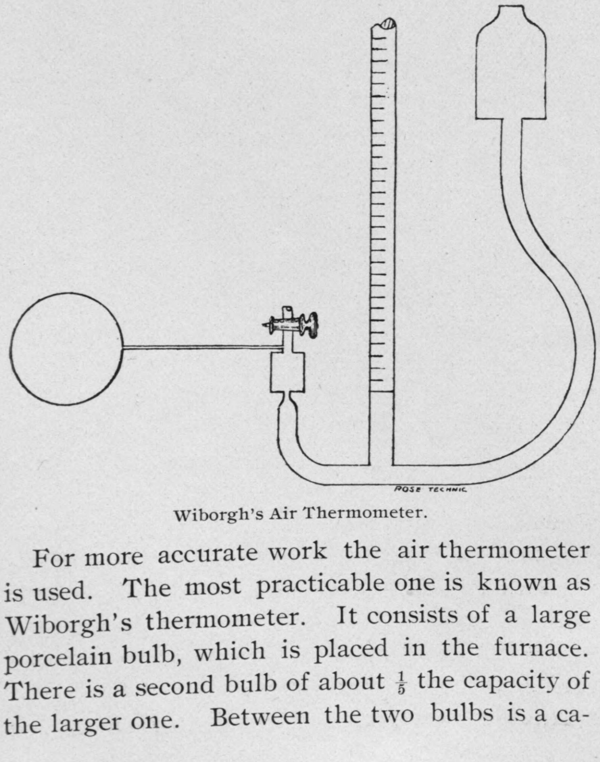
t=temperature of calorimeter.

The iron or platinum ball is dropped in the calorimeter, the amount of heat given off by the ball is just equal to the amount taken up by the calorimeter, and

θ=resultant temperature.

$$M(T-\theta)=m(\theta-t)\times m_1s_1(\theta-t)$$

$$\therefore T=\frac{m(\theta-t\times m_1s_1(\theta-t)\times Ms\theta}{MS}$$



Wiborgh's Air Thermometer.

For more accurate work the air thermometer is used. The most practicable one is known as Wiborgh's thermometer. It consists of a large porcelain bulb, which is placed in the furnace. There is a second bulb of about $\frac{1}{5}$ the capacity of the larger one. Between the two bulbs is a capillary connection, and also a stop-cock. At the lower end of the small bulb connection is made with a reservoir of mercury and an open tube on which there is a graduated scale. There is also a zero reaching at the lower end of the small bulb. The reservoir of mercury may be raised or lowered in order to bring the mercury column to the zero reading at the beginning of the experiment. The stop-cock between the two bulbs is open at the beginning of the experiment and is closed after the large bulb has acquired the temperature of the furnace. The air is then forced out of the small bulb into the larger one by raising the reservoir of mercury. This causes an increase of pressure in the large bulb and the mercury will necessarily rise in the open tube provided with the graduated scale. The increase in pressure will be proportional to the absolute temperatures.

Thus, if the absolute temperture of the air were 300°C., and the pressure were increased $\frac{4}{5}$ of an atmosphere, the absolute temperature would be 4 times the absolute temperature of the air—1200° absolute, or 937°C.

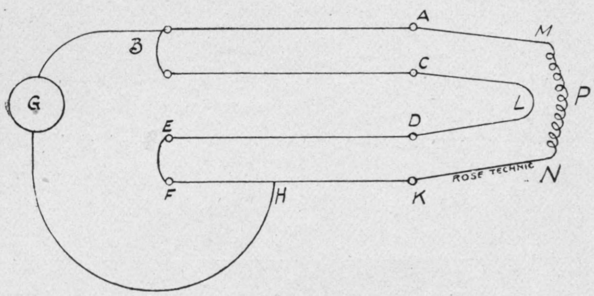
There have been many forms of electrical pyrometers used, but a great many of them are not free from error, from the fact that the zero point does not remain constant for a great range of temperature.

The platinum resistance thermometer is comparatively free from this change in zero point, if the wire is pure and protected from strain. Its resistance when once annealed is always very nearly the same at the same temperature.

The simplest form is made by fusing or welding a coil of fine wire to leads of relatively low resistance. The coil and leads should be inclosed in a porcelain vessel, and should be well insulated with mica.

For accurate work the leads must be of platinum wire, as copper and silver are too volatile for high temperatures, and their vapors attack platinum. Even very small traces of the vapor are sufficient to ruin the wire for thermometric purposes.

The accompanying figure represents somewhat diagrammatically the arrangement of the apparatus;



AB, BC, are equal resistances forming the arm of the balance as in an ordinary postoffice box. The battery is connected at A and C, and one terminal of the galvanometer G at B, D E represents a set of resistance coils, which, together with AB and BC, may be supplied by an ordinary postoffice box. FK represents a straight bridge wire with a divided scale attached. The other terminal of the galvanometer is connected to the contact piece H, which slides along this wire. The leads AM and KN from the pyrometer coil P are connected to A and K, and the compensating leads CL, LD, the resistance to which is equal to AM and KN, are connected to C and D. These four leads may be of any convenient length. They are symmetrically arranged so that the corresponding parts are always at the same temperature. When the balance is found by plugging suitable resistances in the arm DE, and sliding the contact piece H, it is plain that, since the resistances AB, BC are equal, the resistance of the pyrometer and its leads, plus that of the length HK of the bridge-wire, will be equal to the resistance of the remaining portion FH of the bridge-wire, together with that of the coils DE and the compensator CLD. Thus the changes of resistance of the pyrometer leads, AM, KN are compensated by the equal change in the leads CL, LD; and the resistance of the pyrometer-coil itself is directly given by the sum of the coils DE and the reading of the bridge-wire.

It is convenient to graduate the bridge scale so that 100 or 1000 divisions are equivalent to the unit coil in the arm DE. It is also convenient to adjust the resistance of the pyrometer coil so that the change of its resistance between 0° and 100°C. may be equal to 1, 10 or 100 units.

For practical purposes, where only an approximate result is desired, the fusing point of salts are used, A few of the most useful of these are given:

Ca I—621.0°C.
RbI—641.5°.
NaI—661.4°.
KI—684.7°.
KBr—722.0°.
NaBr—757.7°.
KCl—800.0°.
$CaCl_2$—806.4°.
NaCl—815.4°.
$SrCl_2$—832.0°.
Na_2CO_3—849·2°.
Na_2SO_4—863.0°.
K_2CO_3—878.6°.
$BaCl_2$—922.0°.
K_2SO_4—1078.0°,

Saw Filing

By EDWARD T. WIRES.

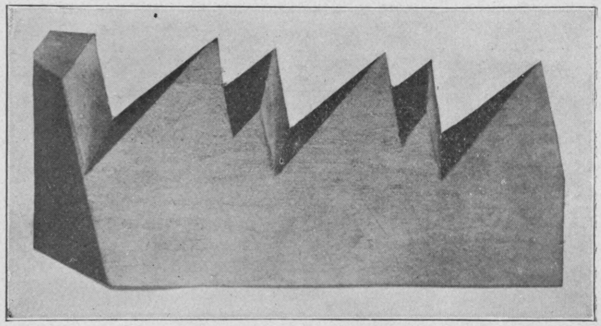
OF all the points made in the training of apprentices, there is nothing more important than the filing of saws.

Few mechanics have the opportunity of filing more saws than their own, unless they are quite successful. Those few are often imposed upon by those who have made failures of first attempts, but who could file if they had a little instruction. This is the class I wish to reach, those who want to learn.

Very few are provided with a good saw vise, and those vises which are on the market are all too short, so one is obliged to change the saw two or three times and thereby lose his position or angle.

It has been my pleasure recently to have made a saw vise to my liking. It is 28 inches long, so that one side of the saw can be filed without moving it. It is provided with two hinged clamps for securing it firmly to a work bench. These hinged joints permit it to tilt to any degree from a vertical position. For cut-off saws I like to lean the saw back 30 degrees from vertical, so that I may hold my file in a horizontal position, as it is the easiest position to keep. File across the saw at 60 degrees out from the handle, and keep the upper surface of the file also in a horizontal position or level both ways. This will produce a tooth with a sharp cutting edge in front and square back. This is the strongest point a tooth can have with so sharp a cutting edge. Some will say that this is all very nice, but how can one who does not possess a degree protractor tilt the saw at an angle of 30 degrees. Lay your file down on one side and its two other sides are 30 degrees out of vertical. Set your level by this to test the angle you wish to lean your saw back to. Notice that the cut on your file is at 60 degrees from its corner and you will have a guide to watch to keep your file at the proper angle to the cutting edge of the saw. Another great help is to put chalk marks on the bench underneath the saw all along so that you can keep in line with them. This is one of the important points necessary to keep the teeth all alike.

For short back saws, that are very fine, I like a vise on a swivel so that I can set my saw at 60° from the front of the bench and file square at the bench, for this is an easy line to keep. While filing with the handle of the saw to the left and the handle of the file swung out to 60 degrees from the cutting edge of the saw, the cuts on top of your file are just parallel with the edge of the



Model Showing Form of Teeth.

saw. Always commence at the right hand end and work to the left. Crowd your file hardest against the large or longer tooth. Always joint the edge of your saw down until you touch the shortest teeth and file only enough to bring all back to points. Don't forget that both sides of the saw are to be filed in the same manner, and don't file too much off the first side. Here you must use your own judgment.

To file a rip-saw is very easy compared with the cut-off saw, as it is all filed from one side and held vertical in the vise. File the front of the tooth vertical and the file will do the rest, if you stop filing as soon as the teeth are brought to points after jointing.

Band-saws are usually filed the same as rip-saws, but for fine scroll work I like them filed with about 10 degrees fleam or about ⅓ the fleam of a cut-off saw, with the front or cutting edge vertical, or with no rake.

Keyhole saws should be filed just this latter way, with set enough to clear easily.

In setting a saw, care should be taken that the teeth shall not be bent at their roots, as this will break the teeth out of a hard saw. The bend should be about one-third up from the root, and should be curved rather than at an angle. Most saw-sets have a sharp angle on their anvils which will produce a crack in a hard saw-tooth and dent it if is soft. For this reason, I prefer a spring to a hammer-set.

FRESHMAN BANQUET.

The evening of December 11th, the Freshman class enjoyed the first banquet of its college career. Sophomores feeding contentedly at their boarding-houses, and perhaps asserting, with the assurance which is the Sophomore's by right, that the banquet of the Class of '04 would not take place until after Christmas, gradually realized that the Freshmen were late to supper. When at last came the knowledge that they had been outwitted, they hurried down town to do their best even under disadvantages. The Freshmen, however, had assembled and were already entering the banquet hall. A small bottle, the present of the Sophomores, which arrived through the window later in the evening, and which caused a temporary adjournment, was the only evidence the banqueters had of the presence of their friends.

Clifton Brannon, the President of the Class, acted as toastmaster. The banquet had been arranged at short notice, and the toasts were informal. The Fair Ones of Terre Haute, The Members of the Faculty, The Freshmen, The Sophs, and other subjects suitable to the occasion, were toasted and roasted in time-honored fashion. Among those who expressed their opinions and sentiments were Knight, Reagan, Staff, Whitten, Adams, Huffaker, Ross and Bryon.

TABLE SHOWING ARRANGEMENT OF COURSES.

Science studies include—

- Physics—Theory and Laboratory.
- Chemistry—Theory and Laboratory.
- Mathematics—Pure and Applied.
- ¼ of the Drawing time.
- Chemical Technology, and Freshman Shop Practice.

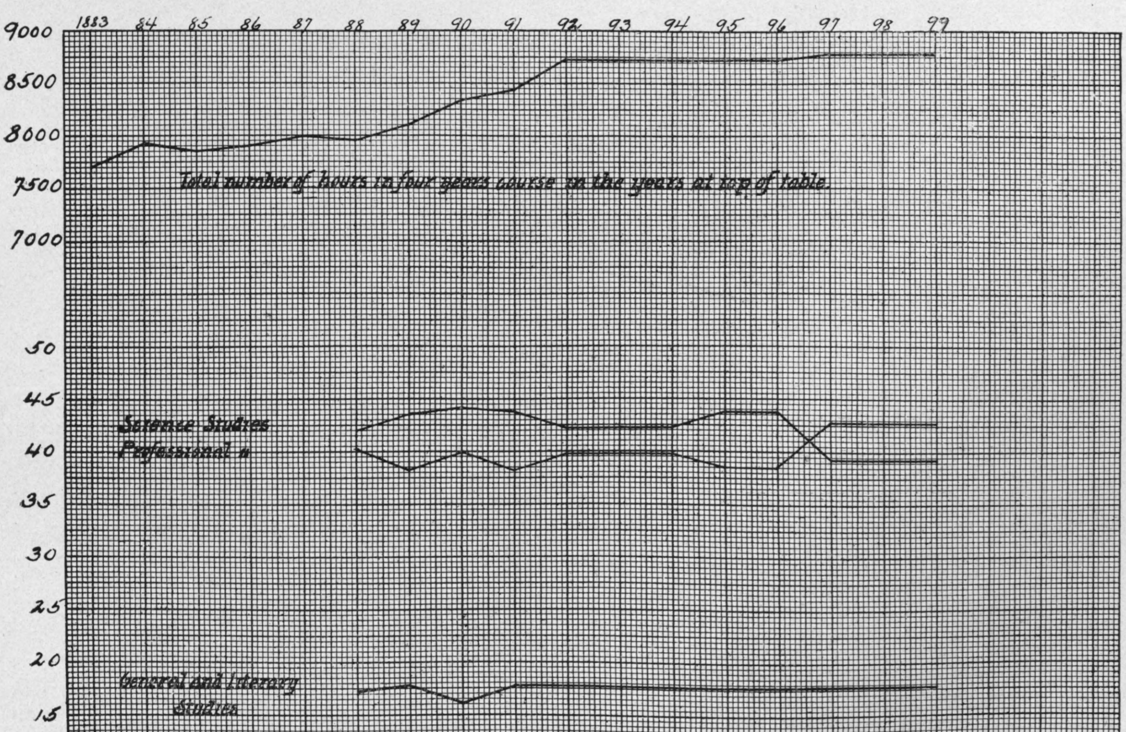
Professional studies include—

- Civil practice and Theory as given in catalogues.
- ¾ of the Drawing.
- Applied Electricity.
- Applied Mechanics.
- Steam Engineering.
- Power Machinery.
- Engineering Laboratory.

General and Literary studies include—

- Political Economy,
- Logic, etc.

The Civil Engineering Course was taken as the basis for these curves, as fewer subjects had to be enumerated in the list. The curves will be nearly true for all other courses. In the Chemical Course the per cent. for professional subjects may be slightly larger.



DIFFERENTIALS

We hear that a Freshman, McF., "seen him do it."

Heinl, to another Freshman—"Yes, that's Dr. Howe."

Kiefer: "If you take those there torpedoes—" And the crowd exploded.

Prof. Wagner: "Now what will be the volume of a cubic foot of air at this pressure?"

Jojo—"Take a solid metal condenser. Now, what do you know about such a hollow sphere?"

Krieger has started out as a collector of income tacks. What he has already collected has come in very easily.

Dr. Mees looks at McFarland, and says that some persons must have mental as well as physical dyspepsia.

Pine—Say, Professor, what shall I do next? I've gotten this white precipitate the book calls "B, I, Double-O, H."

Dr. Blanchard was heard telling a student to "shake that test-tube until the precipitate settles." That isn't so bad.

Bryon says his is an eight-day watch. You wind it eight days and it runs eight hours, and it has a spring eight feet long.

Prof. McCormick waits at the end of the carline with a flat tire. "That's what I get for trying to beat the car company."

"Well, I heard the funniest letter I ever saw, today," was Hammel's rather ambiguous remark on sitting down to dinner a day or two since.

Housum—Say, Powell, what time is it?

Powell reaches into his trousers pocket.

Housum—I didn't ask you for your knife.

A sample of what must be very good iron wire was discovered in the Chemical laboratory. Levi's analysis shows that it contains 100.25% of iron.

Brannon has been experimenting to find at what temperature a saw will buckle. The only trouble with this subject of investigation is that it is hard on the saws.

Troll recently entered class a little late, very much dressed up, and was a little later heard to suggest as a means of measuring volume a liquid which is better known as an intoxicant. It does look just a little suspicious.

In these days of reckless extravagance, it is refreshing to find someone who is really economical. Uhl has recently made the remark that he don't think that sulphuric acid should be used in batteries. "It eats up the zinc, you know," he explains.

Mr. Faurot was recently asked whether there was any difference between the white and green library slips. The seeker after knowledge said he thought that the green ones were perhaps intended for the faculty. The humor was unconscious.

The Sophomores were recently the victims of a grievous disappointment. After tiptoeing downstairs with the greatest care, under the impression that they were cutting drawing, they found on the bulletin board a notice stating that the instructor was sick.

The shops have been invited to help in the construction of a traction engine for farm purposes. The inventor's ideas, as explained to Mr. Clement, were that by a system of gears he could start a three horse-power engine and get any power desired from the machine. This would undoubtedly be economical.

Arnold takes his seat in No. 1 with a self-satisfied air: "It's nice to be first in your class, isn't it?" With a promptness somewhat damaging to the satisfaction, came an echo from the rear of the room: "'And the first shall be last.' No lie, either."

It was perhaps a very good thing that the gentleman who, just before the marks came out, was offering to bet $5.00 to a penny that he would fail, found no one to take his generous offer. It would probably be hard to collect the bet, as he has not been seen since.

Housum was recently heard to advance the theory that when one is attacked by a cold, it is likely to settle in the weakest part of his system. Unkind friends were mean enough to remind him of this statement when he said, later in the day, that he had a bad cold in his head.

Evidently pleased by Cohn's success in projecting himself on the floor in a descriptive class, Kiefer has been trying it, too. For the benefit of others, the cut shows how it is done.

Sophomore contributions to the German language:

Hunley—"Ist dieses Wasser-bottle eine gute squirter?"

"Jemand hat es gesweipt." (Given when requested to translate the sentence, "Where is your German book?")

The "Differential" Editor has of late been greatly puzzled by a recent discovery of his. While waiting alone in a certain well-known office in the Institute one day, he espied on the floor a small leather-covered book. Picking it up, he read on the fly-leaf, "The Green Carpet, Diary." He turned the leaves with great curiosity, and found that the pages were closely filled with script, except that throughout the book there seemed to be impressions from rubber stamps distributed through the text. Before reading any of the remarkable contents of the book so strangely discovered, his eye was caught by the singularity and the recurrence of the many phrases which seemed to have been stamped at intervals in the script. Unconsiously, he ran through the pages, picking out new impressions, as he found them, from the many repetitions which were evident. "I'm doing it for your good," "sever your connection"—what could these mean? Still more mystified, he went on, "best friend you have," "now, do you think that's right?" "my boy, you're burning the candle at both ends"—but just as the interest in the document was at its highest pitch, a firm step sounded in the outer office, and the reader had barely time to get it out of sight when an interview began, to which he had looked forward with some anticipation.

So flurried was the Editor at the conclusion of the little talk, that he did not think of his little treasure until he had gotten well outside the gates. When he did look for it, it was gone, nor was he ever afterward able to find a trace of it. Whether during the short period while his mind was taken up with other affairs, the Green Carpet had claimed it own; why it was that the annals of that fateful room should so oft repeat these mysterious phrases—these are questions of that dark and sinister sort that hang their ponderous and hopeless weight on men's souls. Who can tell?

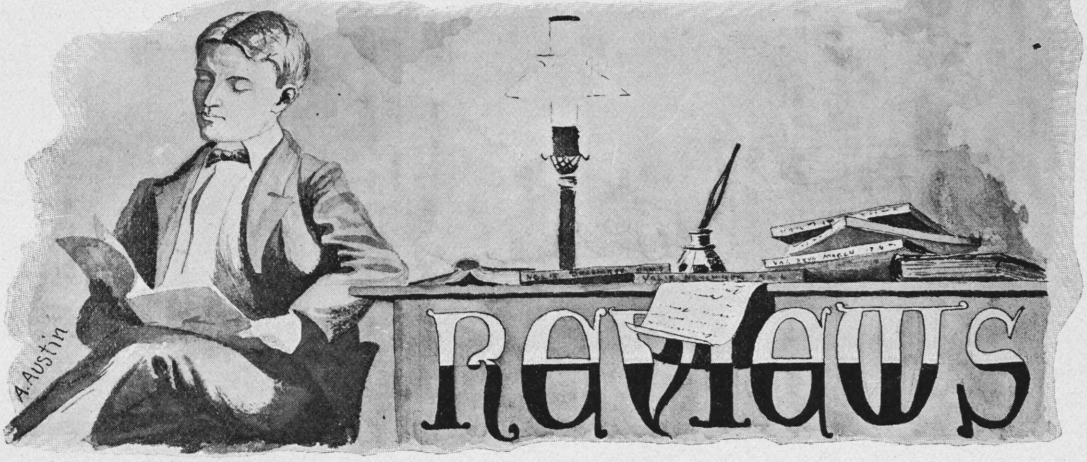
Prof. Kendrick's paper prepared for the Indiana Academy of Science meeting consisted of notes on a study of the potentials required for electrolytic action to take place in neutral solutions of lead nitrate when the electrodes are lead peroxide. At the anode steady action begins at 0.4 volt. At the kathode the indications by the method used were less definite, but it seems clear that the lead is liberated at considerably less voltage than when platinum is used as the kathode, indicating that the lead decomposes the lead peroxide. This seem to occur under 0.7 volts.

On Jan. 12, G. H. Clay, '01, gave a paper before the Scientific Society entitled, "Producer Gas." With the aid of numerous lantern slides, he traced the development of Producers from the first which were made to the newer types which are in more general use today. The wide application which Producer Gas has of late found was illustrated by the number and variety of the Terre Haute industries which employ it. Analyses of the gas obtained from different kinds of coal were also given, and a discussion as to the coals which give the best results from the view-point of economy. Mr. Clay will contribute an article on the same subject to the next number of THE TECHNIC.

Sol says, "He was able to fulfill the place."

TECHNIGRAPHS—IV.

A HOTBED OF GENIUS.



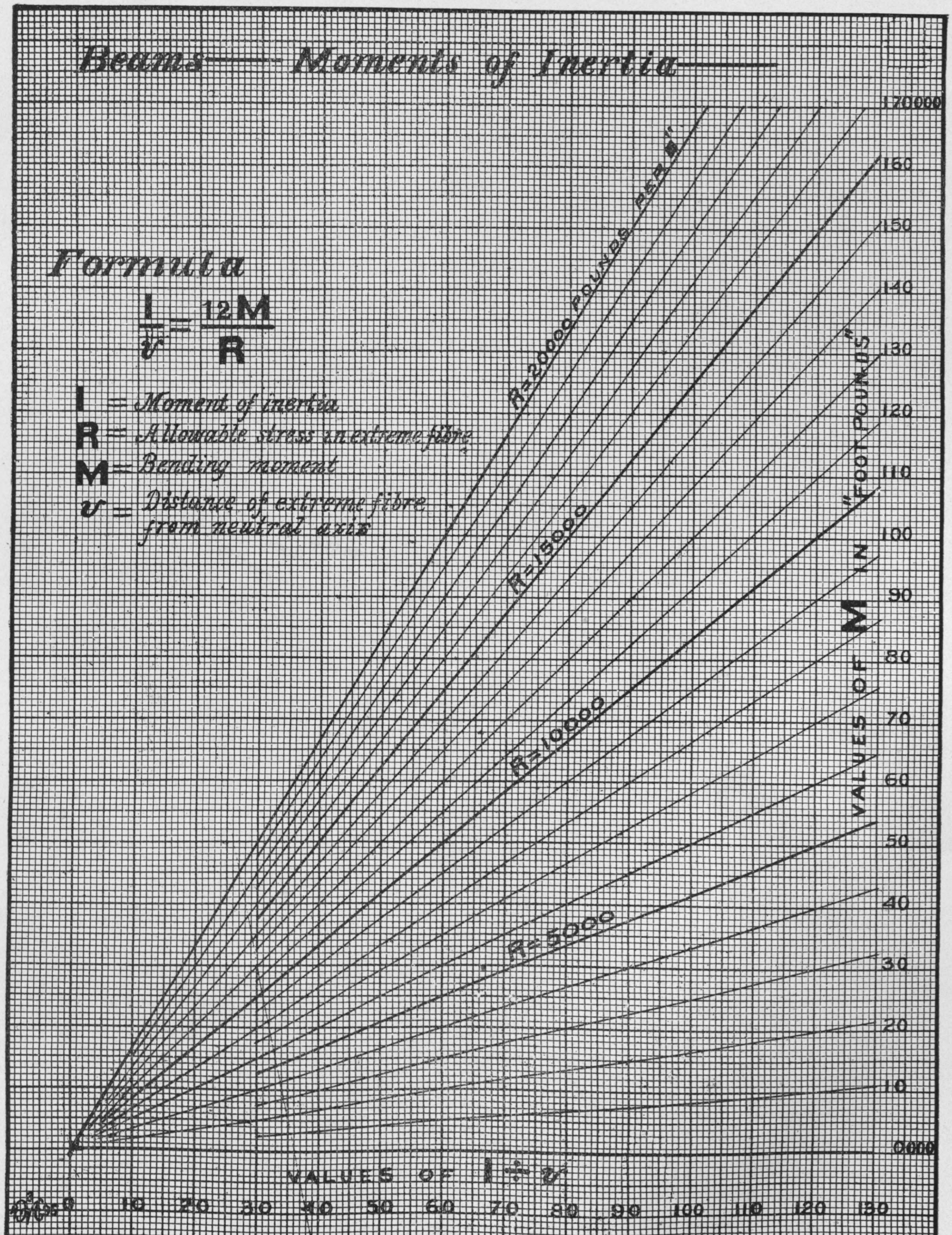
In speaking of the important part played by the engineer in the past century, *The Engineering Record* says:

IT has been his century, and he ought to receive the honors he has earned; he has made it possible for the strong man of keen intellect to live more today in twenty-four hours than he could in twenty-four days in 1800. "Time is nothing absolute; its duration depends on the rate of thought and feeling." The engineer knows, it is true, that the great advancements of the present century must really be traced a little farther back than 1800, back to the time when it became possible to manufacture power on a business basis, to use Mr. Morison's phrase. But although the century now closing cannot claim to have seen the invention of the first successful steam engine, it witnessed the introduction of the engine on a commercial scale and all the great train of attendant improvements.

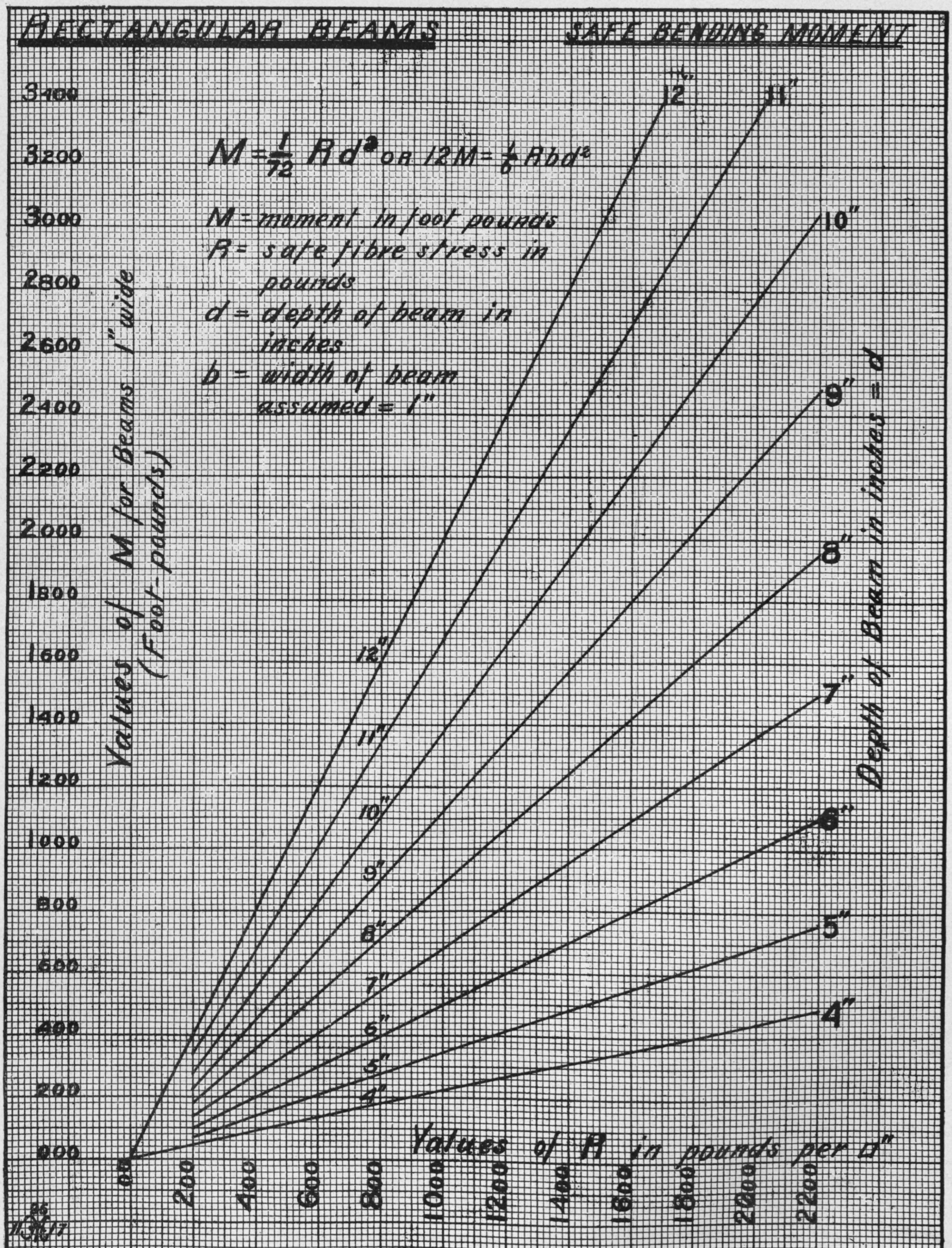
The steam engine, in its stationary, locomotive and marine types, and the telegraph have fundamentally revolutionized the conditions of human work during this century. The manufacture of steel at a low cost, the development of electrical apparatus, the improvement of the printing press, the inventing of reaping and mowing machines, the perfection of the sewing machine and all the apparatus for spinning and weaving, the discovery of new and cheap methods of making paper, the manufacture of hydraulic cements, the design of machine tools of nearly automatic operation, have made life today entirely different from life one hundred years ago. With the improved methods of sanitation due to the joint work of the engineer and physician, they have made existence in great cities enjoyable as well as possible. These inventions, discoveries and improvements have directly affected the daily life of all civilized people, making the luxuries of 1800 the necessities of 1900. But in order that existence shall not be too enervating, the engineer has also provided military apparatus so deadly that the great governments have been forced to draw up at a Peace Conference prize-ring rules for the wars of the future.

It is an acknowledged fact that engineers of the present day are not paid in proportion to the responsibility of the positions which they fill.

A PROFESSIONAL fee for engineering services is not different in itself from a fee for legal or medical advice. It is supposed to be based to a certain degree on the actual amount of work done and to a much larger degree on the skill, judgment and knowledge acquired by previous work and study by the engineer. Whatever is worth having is worth paying for; and the knowledge and judgment which it has taken years to acquire can only be enlisted on adequate compensation. These may seem self-evident truisms, to engineers, at least. It is probably true that they are facts recognized by men of large affairs generally. It was with some regret, therefore, that *The Engineering Record* noticed recently an elaborate defense by an engineer of a bill for professional services rated by no means highly in that memorandum. A fairly well itemized bill needs no apology when rendered for work of the highest class, which few men can accomplish expeditiously and accurately. Advice which means the saving of a great sum proposed for undesirable work may be just as important as that for plans and specifications. It may require as much or more investigation and judgment. A legitimate bill for such advice needs no apology, and, beyond the usual itemized charges, does not call for an unasked explanation. The engineer must stand up for his profession, and conduct his business affairs on the same plane as any other professional man if he is to receive the same rewards for his skill and knowledge. If this were only recognized by him there would be fewer complaints of $50 payments for $250 services. There are all sorts of engineers, just as there are all sorts of lawyers, and their incomes necessarily vary just the same; the best engineers ought to be paid far more than they are, however, in view of their responsibilities, and it rests with them to see that they are so paid.



Beams — Moments of Inertia
Formula
$\frac{I}{v} = \frac{12M}{R}$
I = Moment of inertia
R = Allowable stress in extreme fibre
M = Bending moment
v = Distance of extreme fibre from neutral axis
R=20000 POUNDS PER
R=15000
R=10000
R=5000
VALUES OF M IN "FOOT POUNDS"
170000
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0000
VALUES OF I ÷ v
0
10
20
30
40
50
60
70
80
90
100
110
120
130


RECTANGULAR BEAMS
SAFE BENDING MOMENT
$M = \frac{1}{72} R d^2$ OR $12M = \frac{1}{6} R b d^2$
M = moment in foot pounds
R = safe fibre stress in pounds
d = depth of beam in inches
b = width of beam assumed = 1"
Values of M for Beams 1" wide (Foot-pounds)
Depth of Beam in inches = d
Values of R in pounds per □"
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
000
00
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
12"
11"
10"
9"
8"
7"
6"
5"
4"